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BOVINE ABORTION AND ITS CONTROL.

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(*Prepared for N.V.M.A. Annual Meeting at Chester.*)

MR. PRESIDENT AND GENTLEMEN,

I must in the first place apologise to the meeting for not having already submitted the text of my paper for its consideration. The subject is one of such enormous importance both to ourselves and to the breeding industry of the country that I fully realise the difficulty gentlemen present may experience in embarking on a discussion without having had presented to them some time beforehand the various features upon which I wish to lay particular stress, in order that they might have the advantage of bringing to bear upon these salient points the full weight of their deliberate judgment and mature experience.

When the subject was last put on the programme of the Annual Meeting of the N.V.M.A. in 1906, the Association had the rare privilege of being addressed upon it by no other than the illustrious discoverer of the cause of the common form of contagious abortion in cattle, who eleven years previously had isolated and grown from aborting cows the germ which now bears his name, Bang's bacillus, or *Bacillus abortus* Bang, and proved conclusively the rôle of the organism in the production of the disease. Since the time of Bang's fundamental discovery the most accomplished workers in the field of animal diseases in most civilised countries have been attracted to the study of the condition, both on account of its widespread economic importance and also on account of the fact that the investigation work in this disease calls for prolonged observation and examination of several inter-dependent factors, the elucidation of which demands the sustained interest of trained workers. In the quarterly publication entitled the *Veterinary Review*, which was recently issued for a few years under the editorship of our President, and met with a most pressing need on the part of the scientific worker and the practitioner, who has not usually the time or facilities for keeping in close touch with the many journals wherein are scattered fragments of importance concerning advances in knowledge appertaining to our calling, (but which *Review*, for financial reasons, has been allowed, unfortunately, we hope but temporarily, to lapse), a bibliography was inserted, in the number of May, 1919, containing the names of 225, largely first-rate, articles dealing with contagious abortion of cattle and published nearly entirely since the date of Bang's discovery in 1895. To-day even, this bibliography would not be by any means complete, for more light is being continuously thrown on the disease by field and laboratory workers whose writings frequently appear in current literature. And we still await with great interest the publication of the chain of evidence, bearing in particular upon measures of control, which has been steadily accumulating during a number of years at Research Institutes both in this country and abroad as the result of close co-ordination between field and laboratory workers, and has grown up largely around the circumstance that we now have at hand an accurate and reliable method of diagnosis for the disease.

When, therefore, the esteemed Secretary of our Provisional Committee approached me a couple of months ago, while I was engaged in the pressing duty of preparing for the first time my class in the variegated agglomeration of heterogeneous studies which constitute the function of the Chair to which I had been recently appointed at the Royal Veterinary College, I warned him that I might have great difficulty in handing him my paper within the allotted time, and this difficulty has forced itself increasingly more and more upon my consciousness, for I am aware of the standard of contribution that is expected at the Annual Meeting of the National, keenly sensitive of the fact that I am being asked to submit in review to the meeting our knowledge on a subject exposed to it last by the distinguished Professor BANG, and diffident at the prospect of having to do justice to the voluminous literature contributed by numerous able workers throughout the world. With time and pains I might have been able to place in your hands a neat though somewhat bulky treatise recording systematically the alleged discoveries connected with the disease, and endeavoured to point out what was the sound knowledge in the light of further experience and exact investigation. But as this meeting is composed mainly of practitioners, the problem which interests them most intimately is that of treatment or control, and I propose to limit my remarks to that aspect of the disease as much as possible, dealing only with the other phases in so far as they help to explain the various recommendations suggested.

For some time, there has been an obstinate tendency on the part of lay and many veterinary writers to group together for common consideration a number of clinical manifestations which are frequently found to occur in the animals of a herd affected with contagious abortion. Thus one often sees in the literature contagious abortion, sterility, metritis, and other diseases of the genito-urinary tract, together with many diseases of the new-born, treated as if they all had a common origin and were susceptible to the same methods of treatment. Inasmuch as rational methods of treatment and control can only be devised when such measures are directed primarily towards the causal agent of the disease, it is important at the outset to define clearly the subject we are dealing with based on its etiology. The common form of contagious abortion of cattle in this country, and in all other countries so far as one is aware, is the disease caused by *Bacillus abortus* (Bang).

In the Report of the Departmental Committee appointed (in 1905) by the Board of Agriculture and Fisheries to inquire into epizootic abortion, it is stated, in Part I., published in 1909, dealing with the affection in cattle, "We do not deny that odd cases of abortion may arise from accident or poisoning by such substances as lead, but we have no hesitation in stating that we believe at least 99 per cent. of the outbreaks of cattle abortion which assume epizootic characters are due to infection by the bacillus of cattle abortion, and the fact of a cow having aborted on premises formerly believed to be clean is a suffcient reason for suspecting that the disease has been introduced." This statement, based on McFADYEAN and STOCKMAN's researches for that Committee, still remains as far as one can judge from a perusal of published information substantially true.

Recently, THEOBALD SMITH, in the United States of America, investigated in a herd an outbreak due to another organism. Beginning in 1917, about thirty cases of abortion were studied in which BANG's bacillus could not be found, and in which serological reactions pointing to infection with this bacillus were negative except in those cases in which there had been a history of former abortions. In 1920 the outbreak appeared to have become extinct. The organism isolated by SMITH was described as a spirillum, or vibrio, and it would appear to be quite identical with the organism which McFADYEAN and STOCKMAN had previously found to be the cause of outbreaks of abortion in sheep in this country (*Rept. Dept. Committee*, Part 3, 1913). In fact, these two workers had during their researches on the sheep disease isolated this organism from two natural outbreaks of cattle abortion, one in Ireland and one in Wales, and also proved that it was possible to infect cows experimentally with vibrionic abortion. Again, THOMSEN, in Denmark, in 1920, found the vibrio associated with abortion in four cases out of eleven studied by him in cattle. According to SMITH, the disease of the chorion, due to the vibrio, cannot be distinguished with the naked eye from that due to BANG's bacillus, and it is not possible to distinguish them histologically except during the early stages. "Then we note in the BANG type a more or less universal filling up of the cells of the chorionic epithelium with *B. abortus*. This cell infection extends perceptibly into the cotyledon. When the epithelium has been destroyed other changes follow which lead to an expulsion of the fœtus. In the vibrionic type of the disease the chorionic epithelium remains free from infection. The vibrios are taken up by the capillary endothelium of the chorion, and this process results in thrombosis and occlusion of the affected vessels." It is quite possible that this organism, designated *Vibrio fetus* by SMITH, will be found on further investigation to be the cause of some more localised outbreaks of abortion in cattle in this country.

Infectious abortion in cattle, implying disease of the chorion, may be due to still other specific organisms. For example, THEOBALD SMITH mentions that in a small percentage of cases investigated by him *B. pyogenes* was the only organism that could be isolated from the fœtus; again, a mould of the genus *Mucor* has been found by him to produce fairly extensive disease of the chorion. MOUSSU and others were able to isolate organisms of the *B. coli* type only from some cases, while tuberculosis of the chorion has been also described as a cause of abortion (BANG, THOMSEN). In fact, any organism that is capable of bringing about a condition of endometritis is a possible causal agent of infectious abortion.

Sporadic cases of abortion or premature calving are well known to occur in herds quite independently of contagious abortion, and in herds that have been "cleaned" of the common form of the contagious disease as a result of the systematic application of the agglutination test. Many of these seem to arise without revealing any signs of infection. For example, McFADYEAN notes that in his experience twin calves are frequently aborted quite independently of any infection of the mother (*Jl. Comp. Path. and Therap.*, 1921, Mar., p. 58). Mechanical injury, intoxications, starvation, and general systematic disease are often invoked as causes of abortion.

With regard to mechanical injury, to which may be added other external influences such as fright, shock, odours, and fatiguing conditions, there seems but little doubt that too much importance has been paid to these alleged causes in the past. In other species of animals there is somewhat strong evidence to show that these influences play at times some considerable part in the production of numerous cases of abortion, as when a flock of breeding ewes is subjected to dog worrying or the passage through them of a pack of foxhounds, while mental influences are often alleged to bring about abortion in the human female. Cattle,

however, seem to be singularly well protected in this respect. WILLIAMS (W. L.), who has for a number of years paid a great deal of attention to the diseases of breeding cattle in U.S.A., "points out that abortions due to mechanical injuries are so rare that they may safely be eliminated as causative factors in most cases. He examined the gravid uteri of 1,736 pregnant cows and heifers, and in spite of being on the look-out for injuries to the genital organs, he could find not a single case. He emphasises that these animals had been driven to railroad stations, loaded into cars, transported for many miles, and in many instances unloaded into stockyards, jostled and driven, and finally slaughtered. If such treatment does not induce abortion, the ordinary accidents such as a slip or jar or prod by attendant or riding by another cow, should not be held responsible for the slinking of the calf in many cases" (MOHLER and TRAUM, 28th Ann. Rept., U.S. Bureau of Animal Industry, 1911). In a popular article written for the Journal of the Royal Agricultural Society in 1913, MCFADYEAN notes that "in two instances recently brought to his notice the owners considered it almost certain that the abortion was the result of accident (falling into a ditch in one case, fright and breaking fences in the other), but the agglutination test proved that both cows were affected with contagious abortion."

Intoxication due to the ingestion of frozen, mouldy, or smutty food, ergot infested plants, and "sewage poisoning" was at one time held responsible for abortions, but accurate methods of diagnosis have ruled out most of these, and certainly the last-named, as factors of any importance.

There seems to be some evidence to the effect that starvation is at times a contributing factor, and recently some investigations have been recorded by research workers which would tend to show that a deficiency in certain food essentials is at times responsible for the premature dropping of the fœtus, but these conditions would, however, manifest themselves more particularly as leading to lack of fertility in breeding stock.

Systemic diseases, particularly acute febrile diseases and septicæmic conditions such as the piroplasmoses and trypanosomiases, and cattle plague frequently display abortion as an accompanying symptom.

Although it must be admitted, therefore, that there are some cases of abortion and even of infectious abortion which are not of the common contagious type, due to BANG'S bacillus, "a point which cannot be too strongly emphasised," as MCFADYEAN points out (*op. cit.*), "is that every case of abortion should be regarded as of the contagious kind until the contrary has been proved."

This assertion evidently has as its underlying basis the now generally accepted postulate, that no progress can be made in the control of any contagious disease, including contagious abortion, until measures for combating it are framed entirely upon knowledge obtained concerning the etiology of the disease in question. Later, we shall have occasion to refer to some of the possible after-effects of contagious abortion upon the animal, but with regard to concomitant affections and their relative importance we can only reiterate the view recently expressed by SCHROEDER, who has accomplished much useful work upon this subject as head of the Experimental Station of the Diseases of Animals Branch of the U.S. Bureau of Animal Industry: "It is my opinion that the fight against infectious abortion disease would make better progress if a sharper distinction than now seems customary could be made between this disease and other affections of the female reproductive organs.

"It makes no difference whether infectious abortion disease is due to the BANG bacillus, the SMITH spirillum, the vibrio of STOCKMAN and MCFADYEAN, or some other as yet unidentified micro-organism, the treatment of prior, simultaneous and subsequent evils, like metritis, pyometra, salpingitis, ovaritis, cystic ovaries, etc., accomplishes little more as an actual control measure than, for example, the treatment of scarlatinal nephritis accomplishes toward checking epidemics of scarlet fever.

"Abortion disease, the kind caused by the BANG bacillus, and which available evidence induces me to believe is the only kind among cattle of which we can say with certainty that it is common and widespread, may cause smaller losses in herds maintained under prime sanitary conditions and proper veterinary supervision than in herds under insanitary conditions, but all the sanitation in the world, once the disease has entered the herd, unless definite specific measures, based on its etiology are adopted, can neither check its course nor prevent its spread to other herds. And the sum of all the sanitary precautions that can be practiced will not safeguard a herd against this kind of infection unless it excludes carriers and disseminators of abortion bacilli from it, the seemingly sound and healthy carriers as well as the sensibly diseased.

"Treatment of the various diseases of the reproductive organs, apart from whether they are forerunners, complications, or sequelæ of abortion disease or wholly independent affections, is eminently desirable and economically necessary, and offers an enormous field for practice; but to speak of a miscellaneous assortment of pathological conditions as though they were all abortion disease phenomena and their treatment valuable measures of control of the disease, must inevitably lead to a confusion of ideas that cannot fail to engender uncertainty and timidity among professionally trained men and mistrust among owners of live stock." (*Jl. American V.M.A.*, 1920, June, p. 277.)

Having in mind, therefore, these preliminary and important considerations, it is proposed to pass under rapid review what is now believed to be well established concerning the etiology and

epizootiology of the disease in cattle caused by BANG'S bacillus.

In natural conditions, this disease is essentially a disease of cattle. Recently, extensive outbreaks of abortion in swine have been reported in California, and in the Middle East of U.S.A. by HAYES and TRAUM (1920), caused by BANG'S bacillus; GOOD and SMITH had previously noted the occurrence of this organism in an outbreak in pigs in Kentucky (1916). It would seem in these outbreaks that the disease was contracted by ingesting infective material voided by affected cows. On the other hand, ZEH, in Germany (1920), found an organism of the paratyphoid group which would appear to be very similar to, if not identical with, the organism which is responsible for the common form of contagious abortion in mares (*Bacillus abortivo-equinus*) in the bodies of fœtuses expelled by aborting swine. It is possible that *B. abortus* Bang may sometimes be responsible for a few outbreaks of abortion in mares, but the common cause of contagious abortion in mares in this country, as well as in other countries, is quite another type of organism, the *B. abortivo-equinus* referred to above, and the disease produced by this organism presents quite different epizootiological features. Again, outbreaks of abortion in ewes have been proved by STOCKMAN and MCFADYEAN to be caused by a spirillum or vibrio (*Vibrio fetus*) (*Dept. Committee Report*, Part 3, 1913), and it has already been mentioned that this organism may occasion enzootics in comparatively rare instances among cattle. Experimentally, it has been found quite easy to infect and cause abortion among other farm animals and in small laboratory animals by causing them to be inoculated with, or to ingest doses of BANG'S bacillus, and it is quite possible that even man may become infected; but the natural reservoir of the disease-producing organism is the cow, and there is every reason to believe that just as the bovine type of tubercle bacillus would cease to exist if bovine tuberculosis were completely eradicated, so would BANG'S bacillus no longer persist if the bovine species became extinct. In devising control measures, therefore, other animals than cows need not engage our attention.

ETIOLOGY OF THE COMMON CONTAGIOUS ABORTION OF CATTLE.

Certain Biological Characteristics of Bacillus abortus *Bang.*

The morphological and cultural characteristics of the bacillus first isolated and described by BANG and STRIBOLT are too well known to warrant detailed consideration. Its presence in large numbers, mostly in large clumps, in the affected cotyledons and in the discharges that flow away immediately after the act of abortion, and in small numbers in the digestive tract of the fœtus, and its peculiar oxygen requirements in primary culture, as illustrated by its manner of growth in the "shake" (*serum-gelatin-agar*) media devised for its cultivation by the authors, have been amply confirmed. There is very little difficulty in subsequent transplantations in obtaining abundant growths of the organism on the surface of ordinary laboratory media, aerobically, after incubation at or near body temperature. Another method of isolation devised by NOWAK (1908) and now in common use by laboratory workers is worth mention. This method takes advantage of the fact that newly isolated cultures require an atmosphere partially depleted of oxygen, and growths are thus obtained by growing agar streaks from suspected material in a closed jar in which are also enclosed tubes sown with the rapidly growing, aerobic hay bacillus (*B. subtilis*). This method is particularly useful in obtaining growths from slightly contaminated material, for then the material can be sown in a series of successively weaker dilutions on the agar slants, and incubated at body temperature in the ordinary way for a couple of days; the position of the aerobically growing colonies are noted, and then the tubes are enclosed in the jar with the tubes sown with the hay bacillus. Colonies are usually visible in about four days, and subsequently grow and exhibit the colour changes characteristic of BANG'S bacillus. These colonies can be further identified by growing from them on ordinary agar and testing the agglutinating properties of the strain as compared with a known abortion strain. EVANS (ALICE C.) (1915), in U.S.A., succeeded in isolating the organism by plating on ordinary lactose agar to which ten per cent. of sterile blood serum was added just before plating.

During recent years investigators have also made use of the fact that the abortion bacillus, after subcutaneous or intraperitoneal inoculation is capable of setting up lesions, at least in some countries, in guinea-pigs, especially in the spleen, from which the organism can be isolated. Unfortunately, it is necessary to wait two or three months for the production of these lesions, but SMILLIE (1918) claims that it is possible to grow the bacillus from the spleen or other tissue long before the appearance of macroscopic lesions by smearing small pieces of the tissue on the surface of agar slants, sealing up the tubes, and incubating for a few days. In this way it is possible to recover the organism in three or four weeks.

There is a natural tendency among present-day bacteriologists to class together in families or groups organisms which, though differing considerably in what would seem to be the acquired property of parasitism and pathogenicity, yet present but slight morphological and biological variations. Familiar examples of this sort are those of organisms of the acid-fast group, coliform group, diphtheroid group, etc. It would therefore be natural to enquire whether BANG'S bacillus presents any considerable affinities with any known pathogenic or saprophytic organisms. This question has recently engaged the attention of certain American workers (ALICE C. EVANS, 1916; MEYER and SHAW, FEUSIER and MEYER, 1920).

It would seem from their researches that there is a close relationship between BANG's bacillus and the organism which for some time has been known to be the cause of Malta fever in man, and is transmitted to him usually in the milk of goats and, sometimes, of other animals. MEYER and his co-workers compared cultures of 21 strains of the Malta fever organism (*Micrococcus melitensis*) obtained from various laboratories in the United States, England, Algiers, and Italy, with 32 strains of *B. abortus*, but they had no opportunity of examining the "Micrococcus" direct from any cases of Malta fever. These workers maintain that this organism is in reality a bacillus as it may appear in smears from young cultures and in tissues as a typical short rod, and that the name "Micrococcus" has been kept up largely owing to the conservative attitude of British workers. In particular, they claim that the colour changes of the two organisms on potato media are similar. They conclude that the causative organism of "Malta fever" or undulant fever of man and goats cannot be distinguished morphologically and biochemically from the organism causing infectious abortion in domestic animals. Again, a very careful study of the biological relationship of the organisms was made, and the results of the tests would indicate that certain strains of "*M.*" *melitensis* bear even a closer relationship to the abortion bacillus than they do to other strains of *melitensis* or to strains of *para-melitensis*. They also found that the serum of cows and pigs suffering from natural abortion disease may re-act to both *B. abortus* and *melitensis*. So closely related were the two organisms, that these workers suggest the creation of a new genus *Brucella*, to include the abortion and Malta fever organisms. The writer has been able to confirm this view in so far as a strain of "*M.*" *melitensis* kindly sent to him by the Lister Institute was agglutinated by an anti-abortion serum in almost an entirely identical manner as suspensions of the abortion bacillus, although under the microscope the Malta fever organism had a distinctly more coccoid appearance. There can be but little doubt that the two organisms differ in the all-important property of pathogenicity, for otherwise, in view of what we know concerning the excretion of the abortion bacillus in the milk and the large percentage of cows that act as carriers of the bacillus, a large part of the population of Northern Europe and the United States would be liable to infection. But evidence to hand has failed to prove that the drinking of milk from aborted cows is a source of danger to human beings.

From the point of view of parasitism the two organisms present considerable resemblance. Describing the symptoms of Malta fever in the most frequently affected animals, goats, DUBOIS writes: "In the goat there are as a rule no visible symptoms, and the animals maintain to all appearance their good health, the onset of the disease always passing unnoticed . . . The most important symptom, and the one that would always make one suspect Malta fever, is abortion, but even that is not constant nor is it diagnostic. When the disease makes its appearance in a herd for the first time the percentage of abortions may be anything from 50 to 90 per cent. of the pregnant goats. If these goats are again served, abortion occurs again, but the percentage is not so great as on the first occasion. Abortion may cease completely in a herd, but this does not make the danger any less, as a certain number of animals always harbour the parasite. Sterility is rarely observed." "In the sheep the symptoms shown closely resemble those in the goat, and, as in the goat abortion, is the most important symptom." "In all animals independently of the clinical symptoms the blood serum, urine, and milk possess agglutinating powers for *Micrococcus melitensis*. The value of the (agglutination) test (in diagnosis) is indisputable, but since the serum may retain its agglutinating power for years after all trace of infection has disappeared, a positive result only indicates that the animal is or has at one time been affected" (DUBOIS, *Revue Vétérinaire*, 1911, Mar.-May. Abstracted in *Jl. Comp. Path. and Therap.*, 1911, p. 248).

On the whole the Malta fever organism shows a greater range and much greater intensity of pathogenicity than does the abortion bacillus. It is further of interest to note that in 1914 KENNEDY demonstrated the presence of agglutinins for the Malta fever organism in the milk and blood serum of some cows in London dairies, but failed to isolate the organism from the milk. Additional observations were made on this subject at the time by BASSETT-SMITH (Abstract in *Jl. Comp. Path. and Therap.*, 1914, p. 185).

In view of what we now know as the result of the work of SCHROEDER, COOLEDGE and many others concerning the excretion of agglutinins for BANG's bacillus in the milk of abortion-infected animals, there can be very little doubt that the reactions observed by KENNEDY were provoked by the presence of abortion infection in the system of the cows.

HABITAT OF BACILLUS IN HOST ANIMAL.

Experimentally BANG's bacillus is capable of producing abortion in cattle, sheep, swine, goats, mares, guinea-pigs, and rabbits, as has been satisfactorily proved by numerous authors. Naturally, it would seem that the organism is an obligatory parasite of cattle, in which the only lesion it is ordinarily capable of producing is an inflammatory change in the chorion, resulting in premature expulsion of the fœtus. A few instances are on record of disease of the male sexual organs—testicles, epididymis—caused by the organism. The presence of the bacillus in the body of the animal need not, however, result in an attack upon the gravid uterus resulting in abortion. When the disease first attacks a herd it is well known that a considerable proportion

of the animals abort once, some may abort a second time, very rarely three or more times. It is also known that in the case of a second abortion the fœtus is retained a longer time than in the case of the first abortion. There is now at hand, however, ample direct and indirect proof that infection with the abortion bacillus need not necessarily result in abortion or premature calving, and that cows which have ceased to abort do not recover from infection, but remain, on the other hand, often for many years, carriers of the abortion bacillus. Some direct proof of this assertion has been obtained by examination of the fœtal cotyledons in cases where cows which had previously aborted have subsequently given birth to apparently healthy full-term calves. For example, COTTON (C. E.) states: "Dr. BOYD, of the University of Minnesota, has a Guernsey cow under observation that aborted twice, and since then had given birth to three normal calves. He had succeeded in getting cultures from the placenta after each parturition" (*Jl. American V.M. A.*), 1916, October, p. 13). Perhaps this is a somewhat rare instance of persisting infection. Indirect proof has been abundantly furnished by the results obtained during the systematic application of the agglutination test to herds in which contagious abortion is known to exist. In such herds some cows during the outbreak never abort, and carry their calves to full term, but their blood serum gives a positive result to the test, indicating the development in their bodies of an active immunity, due to the presence of the organism. Positive results to the test never occur in herds in which contagious abortion does not exist or has not existed at some anterior date. It would, therefore, be natural to conclude that the reacting cows which have not aborted in the affected herd were infected and remained carriers of the organism. Moreover, in cows that have aborted and subsequently given birth to normal calves, repeated serum tests indicate a long persistence of the disease in a large proportion of the cases. This experience has been borne out by numerous investigators. In the records of one of the herds dealt with by MCFADYEAN, details of which were recently published, some cows were found to react for seven years after the act of abortion (*Jl. Comp. Path. and Therap.*, 1921, March, p. 48).

Considerable light has been thrown on this question of persisting infection by the recent researches of workers in the United States of America—particularly at the Bureau of Animal Industry and Michigan Agricultural College. It would be natural to ask whether the infection persists in the uterus or whether it is capable of establishing itself elsewhere in the body of the cow. It would appear, however, that the bacilli do not persist for long in the non-pregnant uterus. "When an infected cow has aborted or calved, irrespective of whether the calving is or is not attended by sensible abnormal phenomena, the uterus and the material discharged from it may, and in a large proportion of cases do, contain abortion bacilli. The infected condition lasts for a few days to a few weeks. As a common rule, tests to discover abortion bacilli in the uterus three weeks after abortion or parturition give negative results, though we have one case on record in which they persisted nearly two months. The latter must be looked upon as a rare exception. When abortion bacilli are injected into the non-pregnant uterus they disappear in a few days, and judging from numerous tests made at œstral periods and at other times, copious repeated injections of suspensions of abortion bacilli into the veins of non-pregnant cows do not infect the uterus" (SCHROEDER, *Jl. American V.M. A.*, 1920, January, p. 372).

It had been noted in laboratories that guinea-pigs inoculated subcutaneously or intraperitoneally with milk from cows suspected to contain tubercle bacilli developed afterwards, if allowed to survive six weeks or longer, lesions in the spleen and sometimes in the other tissues that bore a very close resemblance to tuberculous lesions, but which, on careful search, could not be found to harbour tubercle bacilli. SCHROEDER and COTTON (28th Annual Report, Bureau of Animal Industry, 1911) discovered in such lesions organisms quite indistinguishable from the abortion bacillus. THEOBALD SMITH and FABYAN, somewhat prior to this date, had noted the occurrence of extensive tubercle-like lesions in guinea-pigs, inoculated with material from the diseased cotyledons of aborting cows. Subsequently tests of numerous samples of milk convinced SCHROEDER and COTTON that the milk was a common avenue of escape for the abortion bacillus, and that "the favourite habitat of the abortion bacillus in the bodies of cows is the udder, and the udder is seemingly its only habitat in the bodies of non-pregnant cows." The excretion of the bacillus in the milk of reacting cows as proved by guinea-pig inoculation has subsequently been abundantly corroborated by other workers in America and elsewhere.*

The extensive changes in guinea-pigs reported by American workers and by SEDDON, in Australia, do not appear to occur universally, however, and in a large number of samples of milk inoculated by ROBINSON, in South Africa, comparatively only few gave rise to distinct tubercles in the spleen, although the distinct swelling of this organ reported by these workers was commonly noted. In a few tests performed by the writer he was unable to observe the production of gross internal changes in guinea-pigs as the result of inoculation, even with a recently isolated strain of the organism, although it could be easily recovered for some time afterwards in cultures made from the spleen.

*Something analogous to this phenomenon is seen after the introduction of tubercle bacilli of the so-called human type into the body system of cattle. The possibilities of vaccination against infection due to the bovine type by this process were recently somewhat extensively investigated. Although the method was found to be effective and no macroscopic lesions were set up, yet the passage of virulent human tubercle bacilli for a long period in the milk of the vaccinated animals has now caused it to be abandoned as a practical measure for controlling tuberculosis.

SCHROEDER and COTTON then showed that abortion bacilli injected into the veins of normal non-pregnant cows disappeared from the circulating blood in the course of a few hours; "and when such cows were killed some time afterwards, though their blood had become positive with agglutination tests, the germs could not be found in their bodies, unless it was in their udders and associated lymph glands. One case in the records is remarkably impressive as an illustration of the tendency of abortion bacilli to lodge in the udder. The case is that of an adult, virgin, female animal, a heifer, approximately four years old, which was given an injection of abortion bacilli into one of her jugular veins. Later it was found that the infection (the abortion bacilli) had established itself in her virgin udder, which was not functioning and never had functioned" (*Jl. Agric. Res.*, 1917, p. 10).

Very numerous tests made by SCHROEDER and COTTON upon milks from cows that had reacted to the agglutination test showed that the bacilli could frequently be detected in the milk independently of whether the reacting animal had aborted or not. In some of the cows the milk was infected with bacilli continuously, and in others intermittently. Milk from some cows disclosed bacilli year after year, while milk from other cows was infected for shorter periods. In one case a cow was proved to harbour the organisms continuously in her milk for up to seven years. Again, "a number of calves produced by cows with infected udders were killed immediately after they were born, and their bodies tested for the presence of abortion bacilli through guinea-pig inoculation methods. It was found that such calves—those that were delivered alive and seemingly healthy and vigorous—may harbour abortion bacilli in their stomachs and gastro-hepatic lymph glands, but invariably, when the calves were infected, the afterbirth and uteri of the dams were also infected."

These authors also demonstrated the possibility of infecting a cow by inoculation via the teat canal. This cow was proved to be "clean" prior to inoculation, and had been served by a clean bull. There was subsequently a very marked local production of agglutinins in the injected quarter, a less marked reaction in the other quarters, and a fairly distinct reaction in the blood serum. About seven weeks after injection the cow gave birth at full time to an undersized weak calf, which, however, soon recovered. There was retention of the afterbirth, which on removal was found to "contain much abnormal material of a yellowish colour, and this was proved to be infected with abortion bacilli." Vaginal discharge proved infective for 17 days. At birth the calf's blood serum gave a positive reaction, identical with that of its mother, but it gradually declined and had ceased completely 45 days later. The cow's blood serum retained a constant reaction, but the titre of the milk declined considerably after parturition.

An important point is that the abortion bacillus was never found in the milk of a cow unless both her milk and her blood serum possessed agglutinating properties for suspensions of the bacilli. But milk from reacting cows did not invariably show the presence of the bacilli. Much the same conclusions were derived by COOLEDGE, who also carried on a large number of experiments almost simultaneously upon this question at the Michigan Experimental Station. Confirmatory evidence has further been obtained through the works of SEDDON, in Australia, ROBINSON, in South Africa, and others.

We may, therefore, take it as fairly established that when abortion bacilli gain access to the tissues of a cow, they invade the uterus if it contains a fœtus and there multiply, producing disease of the chorion. This may be extensive and result in premature expulsion of the fœtus at any time after conception. How soon after infection the fœtus becomes expelled may vary considerably. There is reason to believe that in some cases the bacillus multiplies very rapidly in the chorionic tissue, with resultant abortion, inasmuch as tests of sera from the cows a short time prior to the act fail to indicate infection. On the other hand, the fœtus may be carried to full term and delivered normally, in spite of slight chorionic invasion. The uterine changes produced by the abortion bacillus are very slight, and provided secondary infection does not set in, as does frequently happen after retention of the placenta, which is a common sequel to abortion, the uterus cleanses itself of infection with the bacillus fairly quickly, and is again in a fit state for conception. At least, such would appear to be the inference one can gather from careful histological and bacteriological investigations (SVEN WALL, *Report, International Veterinary Congress*, 1914; SCHROEDER, *et al.*).

In the virgin or non-pregnant female the abortion bacillus establishes itself in the udder only and associated lymphatics, where its presence can be revealed by its passage in small numbers in the milk (or expressed udder secretion), and in this location it may persist for many years, and during this time the blood serum of the animal reacts positively to the agglutination test. According to SEDDON, however, a certain percentage of cows become infected in the uterus, and subsequently may recover completely from that infection (in his cases, 6 out of 63, *i.e.*, 10 per cent.). (*Jl. Comp. Path. and Therap.*, 1919, p. 28).

It is now well known that serum tests on bulls in affected herds give evidence of infection. SCHROEDER and COTTON (*op. cit.*) while investigating this problem discovered two cases in which lesions were discovered post-mortem in reacting animals. One bull showed the presence of an abscess involving the epididymus of one testicle, from which BANG'S bacillus was isolated. The other animal was allowed to serve a cow that was considered to be free from abortion disease.

Seminal fluid recovered from the vagina immediately following the service was proved to contain rare abortion bacilli by guinea-pig inoculation. In three positive reactors investigated by RETTGER and WHITE neither lesions nor presence of bacilli could be demonstrated in two, but in a third animal there was an abscess in the region of the groin, from which, however, they were unable to isolate the abortion organism. BUCK, CREECH, and LADSON (of the U.S. Bureau of Animal Industry) (1919) discovered 37 positively reacting animals among 325 mature bulls tested. The vesiculæ seminales, deferentia, testes, and epididymides of the positive bulls were subjected to a cultural examination, with the result that *B. abortus* was demonstrated in four, and in two of these there were also present lesions, involving the vesiculæ seminales. These four bulls had somewhat high agglutination reactions.

SEDDON (1919) was able to show that the abortion bacillus is able to establish itself, with the production of visible lesions, in the testicle of a young bull (three months old) after intravenous inoculation, and to persist in that animal for at least 182 days.

In spite of these findings, it would seem that the reservoir of infection in the bull has not yet been satisfactorily located.

Diagnosis.

In the case of contagious animal diseases such as tuberculosis and glanders, which are often characterised by their lack of outward manifest symptoms in the affected subjects, it is now a familiar doctrine that progress in their eradication cannot be obtained until one is able to single out the carriers of latent or slowly progressing infection and eliminate them from proximity to the still healthy subjects. The diagnostic agents known as tuberculin and mallein, therefore, are weapons of well-established efficacy in controlling the diseases mentioned. It was natural that researchers should therefore endeavour to find out whether a product manufactured from the causal agent of contagious abortion in a manner analogous to the above would be of comparable efficacy in the diagnosis of contagious abortion. "Abortin," as it was called, was prepared by MCFADYEAN and STOCKMAN in their work for the Departmental Committee on Epizootic Abortion (1905-1909), and tried on a number of experimentally infected cattle with promising results. Experience in the field, however, did not prove that this reagent was of such value as one might have expected. It was found both in this country and abroad that the test in many instances failed to pick out infected animals, and hence it has been now everywhere discarded in favour of a simple laboratory test.

Following on the success of serum tests in other diseases, such as, for example, typhoid fever in man and glanders in horses, it was also natural that these should be exploited in the case of contagious abortion.

The agglutination test depends upon the property which the blood serum of an animal acquires for clumping together pure cultures of a specific organism, held in fluid suspension, when the animal's body has become invaded with the germ in question. It was first tried in contagious abortion by MCFADYEAN and STOCKMAN during the investigations referred to above, and almost simultaneously by HOLTH and WALL, in Denmark. Having in mind, no doubt, the inadequacy of the test on glanders, the first-named investigators did not hold out great hope in their first communication, but their own subsequent work on a large number of animals, as well as the researches of workers in every country in which contagious abortion exists, has established the value of the test beyond all dispute. The complement-fixation test, depending also upon the manufacture in the affected animal of a substance which can be demonstrated by its affinity for the specific organism outside the body, has been found to give reliable results, but inasmuch as its employment in the laboratory is somewhat laborious and general experience does not indicate any appreciable superiority over the simpler agglutination test, it is not now used in routine diagnosis.

The precipitin test, which makes use of the fact that blood sera of affected animals are capable of forming an albuminous precipitate when placed in contact with clear liquid extracts of the infecting organism, has been tried and found to be quite capable of furnishing reactions, but the results do not appear to be in concordance with those of the other tests; it seems that there is room for further work on the value and indications of this test.

It is beyond the scope of this paper to discuss the technique of the agglutination test. Briefly, it may be stated that a strong reaction is indicated when very minute quantities of serum are capable of clumping together the suspended organisms in an emulsion, and causing them to fall to the bottom of the tube, thus rendering the fluid water clear on standing. The agglutination "titre" of the serum is expressed by the ratio which the volume of the smallest amount of serum required to produce complete or distinct clumping, or "agglutination," bears to the volume of bacterial emulsion to which it is added, after having been allowed to stand in an incubator or in a water bath a stated length of time:—1/50, 1/100, 1/200, 1/1000, 1/2000, etc. Following upon the lead of WALL, many workers express the titre in amounts of serum added to unit quantity of emulsion:—·05, ·02, ·01, ·005, ·002 c.c. From a perusal of the literature, it seems that there is no fixed standard among investigators as to what titre indicates a "reaction" in this test. While some consider a distinct reaction in 1/25 dilution as evidence of infection, others would seem to imply that agglutination taking place only in dilutions below 1/100 indicates the presence of non-specific or normal agglutinins, which are not evidence of infection. That there is usually a well-marked difference

between the highest titre of normal sera and the lowest titre of sera from infected animals has been well brought out by numerous researches, particularly those of SEDDON. But lack of uniformity in the appreciation of results seems to be due to the fact that there is no common system of expressing the actual quantity of organisms in the suspensions used for the test in different laboratories. It can be readily proved that the thinner the suspension used the higher will appear the agglutinating power of the serum added to a given volume of fluid. Attempts to attain uniformity in this respect are made in some laboratories by comparison of the emulsion used with tubes of standard capacity, as with the use of MCFARLAND'S nephelometer. Otherwise, an actual count of the organisms is indicated, and in subsequently made "brews" of emulsion the new emulsion can always be accurately compared with the previously made one by means of the disappearing platinum loop method now in common use in laboratories. In recent infections there will, of course, be found cases in which the results are doubtful owing to the presence in low dilutions of partial reactions only. If re-tests are made of serum from the same animal a few weeks later, when the recent invasion will have had time to assert itself upon the animal's system, a positive result can readily be obtained.

A question of considerable importance is how long after actual infection does a reaction, as exhibited with the agglutination test, become evident, because, as is well known, after infection with other micro-organisms a certain period must lapse before agglutinins are demonstrable in the blood. WILLIAMS (W. L.), of New York, asserts that a large percentage of cows abort before a positive reaction to the test is obtainable. The experience of other investigators seems to contra-indicate this view. It must be admitted, however, that tests performed on cows a rather short time before an actual abortion sometimes fail to furnish evidence of infection. In the first report of herds treated by the segregation method, MCFADYEAN gives details of a cow that aborted within three weeks after having given a quite negative result to the agglutination test. Her blood after abortion gave a distinctly positive reaction (*Jl. Comp. Path. and Therap.*, 1921, p. 53). From experiments in which young cattle were inoculated or infected artificially by way of the natural channels, MCFADYEAN, SHEATHER and MINETT concluded that "either of the tests (the agglutination and complement tests) may give positive results within from seven to twenty-one days after infection. In animals in which the result of the agglutination test is negative three weeks after the attempt to infect, it generally remains negative, and indicates that the animal has not become infected" (*Jl. Comp. Path. and Therap.*, 1913, p. 170).

The persistence of the reaction over long periods after having once aborted naturally has already been referred to above in discussing the carrier question. Sometimes, however, as noted by SEDDON, in about 10 per cent. of his cows, the reaction soon disappears. In young animals inoculated with cultures injected by natural channels, the reaction tends to die out in from a few days to a few weeks (MCFADYEAN and others, 1913; HUDDELSON'S milk feeding experiments, 1918). Calves at birth often exhibit no reaction when born from infected mothers, but react slightly subsequently for a few weeks when fed on the naturally infected milk of the mother. Subsequently they cease to react to the test, and virgin heifers are rarely found infected. Animals vaccinated as heifers with young cultures of the abortion bacillus may show persistent reactions for three years after inoculation, although in the majority of cases the reactions disappear earlier (MCFADYEAN, *Jl. Comp. Path. and Therap.*, 1921, March).

Identification of the organism in the discharges that come away from an animal soon after the act of abortion is obviously another important method of diagnosis, and recently guinea-pig inoculation has been extensively employed in order to ascertain the presence of small numbers of the organism, as they occur, for example, in the milk or udder, or in the tissues of the fœtus. Search is made for the characteristic nodular lesions after an interval of six weeks or longer, but in reality infection of the guinea-pig can easily be determined by taking a few drops of blood obtained by pricking or cutting down lightly on to the marginal vein of the ear in about a couple of months after inoculation and testing the expressed serum by means of the agglutination test. The reaction is usually not seen until over a month or longer has elapsed if minute numbers of bacilli are injected, but when it does occur it persists for nearly two years after infection.

Agglutination tests may also be performed on the milk, either by utilising the milk itself where high dilutions are employed, or better by utilising the whey obtained after the separation of the opaque curd by the action of rennet. A reaction is usually obtained with the milk when there is also a positive blood serum reaction, but COOLEDGE and others have definitely shown that the milk reactions are not always strictly proportional to the serum reactions. When the milk is positive the serum is positive, but sometimes milk from one quarter may show a considerably higher titre than that of milk from other quarters, or that of the blood serum. In such cases guinea-pig inoculation shows infection of the quarter from which milk with the highest titre was drawn. The hind quarters are the ones most commonly found infected. If the milk from all quarters display uniform reactions, then it is lower than that of the blood, and guinea-pig inoculation is usually negative.

EPIZOOTIOLOGY: MODE OF INFECTION AND METHODS OF SPREAD.

It will be readily agreed that by far the most important source of infection is the affected fœtal

membranes and their contents that come away after the act of abortion. The diseased parts of the chorion are teeming with bacilli, which are also to be found in small numbers in the body of the fœtus; even when the calf is born at full term the chorion may have localised areas of infection. The discharges that subsequently come away are infective for a limited period of time, as mentioned above, although it may be difficult or impossible to identify the organism in these discharges owing to secondary invasion with other organisms.

Again, since the presence of the organisms has been definitely ascertained in the milk of infected cows, this fluid remains a potential source of infection. It has been suggested that for this reason the fæces passed out by the sucking calf may prove infective. However, the organisms are present in small numbers only usually in the milk, and feeding with such milk has invariably failed to set up anything more than transitory signs of infection in calves. The milk or whey of infected udders has recently been demonstrated by HUDDELSON (*Jl. American V.M. A.*, 1916, Nov., p. 261) to have a very high bacteriolytic power, which might play some part in modifying the virulence of the excreted bacilli. However, this author seems to have shown that cultures of the organism fed over a considerable period to a calf in the milk of non-infected animals are not infective. There seems to be no record of tests of infectivity of the fæces, and itwould be difficult to demonstrate the presence of the organism in such material.

In a few cases, as has been mentioned before, the presence of organisms has been demonstrated in the genito-urinary tract of the bull, and SCHROEDER and COTTON have ascertained its presence in the semen. The chance of infection via this material is, however, admitted to be small, for cows served later by three such bulls passing the organisms in their seminal fluid (one naturally infected and two artificially infected), at the Experiment Station of the United States Bureau of Animal Industry, failed to become infected (SCHROEDER, *Jl. American V.M. A.*, 1920, January, p. 374). The expulsion of the organisms along this path, however, is not necessarily limited to the time of copulation.

We have therefore four sources of infection to be taken into account in our efforts to combat abortion disease, viz., first, and most important, the uterine contents of the affected cow; secondly, the udders of infected cows; thirdly, the discharges from the bowels of unweaned calves; and,fourthly, bulls with infected reproductive organs.

How long the organism persists in a virulent form outside the body we do not know. MCFADYEAN and STOCKMAN obtained actively growing cultures from exudate that had been stored in fluid for six and seven months, and such cultures were used to infect three heifers. Material stored in a non-putrid state for a year, however, failed to infect. Dried exudate failed to infect after four months. These authors moreover suggest that "pregnant bitches and vixen may become infected by eating virulent material, and by afterwards aborting furnish another means of keeping up and spreading virulent material" (*Report Dept. Committee*, Part 1, 1909).

Conditions are, however, different when the infective material is allowed to become the rich breeding ground of putrefactive organisms, and it is highly probable that these exercise a modifying influence upon the longevity of the organism. Some American workers recently claim to have demonstrated a toxic action produced by cultures of a milk organism—*Bacillus bulgaricum*—upon the abortion bacillus.

Materials soiled with any of these discharges are potential spreaders of the disease, and the next question of great importance is how does the organism gain entry into the animal body. Experimentally, the disease has been transmitted quite readily by inoculation or by way of the natural channels, such as by feeding, the vagina of the female and the prepuce of the bull, or via the teat canal.

At one time the common belief was that infection gained entrance to the body by way of the genital tract,and that the most frequent method by means of which it was conveyed to this channel was by means of the penis of a bull that had previously been used for serving infected cows. It was also held that the contagion frequently gained admission along this path from drain channels and other sources soiled with the discharges of infected cows. Following the lead of NOCARD, detailed measures were drawn up for the disinfection of the vaginal passages and surrounding parts of the body of breeding cattle in infected surroundings.

There was, it seemed, considerable clinical experience to show that the disease was often carried to healthy animals in this manner. In the paper read by Professor BANG before this Association in 1906 it was stated "that *copulation* must afford the most favourable opportunity of all for infection, as that is the only way in which a direct introduction of the virus can be effected." In support of this view he cited the striking example of POULSEN, which has since been much quoted in the literature: "A farmer who owned 16 cows, among which abortion had never occurred, nine years ago allowed seven of his cows to be served by a bull at a neighbouring farm where abortion had prevailed for some years; all these seven cows aborted, and no other. When the cows began to show signs of impending abortion they were immediately removed from the byre and put into another stall. By all seven cows the after-birth was retained, and Mr. POULSEN, therefore, had it removed by hand within 24 hours. The removal was complete in the case of six of the cows, but not in the seventh, which became emaciated, and was soon afterwards sold. After removal of the after-birth the cows were for some time daily washed out with carbolised water, and they were not re-admitted to the byre until some considerable

time afterwards, when they appeared to be entirely free from discharge. During the following year the six cows again became pregnant and carried their calves to full term. No case of abortion has since then occurred in this herd." Later, however, BANG mentions two experiments in which he succeeded in producing the disease in pregnant cows by feeding them with cultures or diseased cotyledons, thus proving "in an incontrovertible manner that a pregnant cow may be infected by eating parts of an after-birth of an aborting animal or fodder soiled by discharge from aborting cows."

Since the date of BANG'S paper the possibility of the bull acting as a disseminator of infection has engaged the attention of several investigators, and there is now abundant evidence to hand to show that the disease is conveyed but rarely in this manner. Of prime interest in this connection are the researches performed by MCFADYEAN and STOCKMAN for the Departmental Committee on Epizootic Abortion (Report, Part I., 1909). After having confirmed the discovery that infection can readily be brought about by ingestion of virulent material, they state, " Most of the circumstantial evidence which seemed to establish the bull as a factor of the first importance admits of another and more probable interpretation. For example, it was held that when heifers which had never been in the infected byres aborted at pasture, they must have been infected by the bull; but in such cases we are now in a position to say that if recently aborted cows have grazed on the pastures, the heifers may have been infected by swallowing grass or water contaminated by the discharge from the genitals of the former, or that virulent material may have been conveyed on artificial foodstuffs from the buildings. Without denying that the disease may sometimes be spread by coition, we think that nothing more than a quite subsidiary role in the spread of epizootic abortion can be assigned to the bull." One experiment is reported by these workers in which they failed to produce abortion in a healthy heifer by allowing her to be served by a bull that had thirteen days previously been used to serve an infected cow. Little importance, however, is paid to this single negative experiment.

It has been stated, on the other hand, elsewhere in this paper that bulls nevertheless often actually become infected with the disease. Experimentally it has been found possible to produce signs of infection, as evidenced by subsequent blood tests, after introducing the bacilli into the body by any of the ordinary methods, including instillation into the sheath (MCFADYEAN, 1913). On rare occasions signs of disease have been noted in connection with the genital organs, and the bacilli have been demonstrated in the seminal fluid. In spite of these findings, recently performed experiments have failed to give proof that the disease can be conveyed even by a bull discharging infected semen. SCHROEDER states: " At the experiment station of the Bureau of Animal Industry it was proved that the seminal fluid of one naturally and two artificially infected bulls were contaminated with abortion bacilli. Cows served by these bulls have remained entirely free from abortion disease. Service occurred on neutral ground, where the exposure of the cows to the bulls was limited as strictly as possible to the act of copulation. The injections of suspensions of abortion bacilli into the uteruses of cows just prior to copulation has failed to infect them. The evidence that other workers have obtained relative to the infection of the cow with abortion bacilli at the time of copulation fails to incriminate the bull. This is all perfectly compatible with the rapid disappearance of abortion bacilli from the non-pregnant uteruses of cows. The habitat of the abortion parasite in the pregnant uterus is the chorionic epithelium or something else which does not exist prior to or at the time of copulation " (*Jl. American V.M.A.*, 1920, Jan., p. 374).

Experimental proof that the bull is a factor of little importance has also been supplied by the researches of HADLEY and LOTHE (1916) of the Wisconsin experimental station. In tests on 5,000 head of cattle carried out over a period of four years, HADLEY and LOTHE discovered that no more than 25 per cent. of the bulls in infected herds furnished positive reactions, while about 36 per cent. of the cows showed evidence of infection. In order to ascertain, therefore, whether the bulls were carriers of the disease, experiments were planned in which two bulls that had been regularly serving infected cows and themselves showed signs of infection were used to serve ten clean heifers, which were subsequently kept in a clean environment. None of these animals developed signs of infection as the result of these services. The following season seven of them were served by three clean bulls and placed in an infected herd. Three of the heifers developed positive blood reactions. (*Jl. A.V.M.A.*, 1916, Nov., p. 143.)

ROBINSON, in South Africa, further infected a bull by inoculation and allowed it to run with eight clean heifers, which subsequently calved normally and showed no signs of infection (*5th and 6th Reports of Director of Veterinary Research, p.* 347).

Again, it is well known that abortion often does not occur until pregnancy is very far advanced, so that one would have to assign a much longer incubation period for this mode of transmission than is known to be required after infection by other channels. Further, agglutination tests carried out on herds in which abortion occurs sometimes fail to disclose the presence of infection in the system until the act of abortion is somewhat close at hand.

There are on record, moreover, field observations which go clearly to show that the bull is not a serious factor in the spread of the disease. For example, HADLEY and LOTHE (*loc. cit.*) state: " We have in mind a farmer who purchased some pure-bred cows at a public sale. These cattle

HUDDELSON'S EXPERIMENTS.

	CALF.			DAM.					
No.	Milk Fed.	Serum Reactions. Agglutination.	Serum Reactions. Complement.	Age.	No. of Normal Births.	No. of Abortions.	Serum Reactions. Before parturition.	Serum Reactions. After parturition.	Milk Reaction.
(1) 995	Naturally infected :— For 4 weeks.	At birth — 1-3 weeks apprec. Subseq. —	At birth — 1-3 weeks dist. Subseq. —	2	1	Nil	—	+	+
(2) 996	Naturally infected :— For 12 weeks.	At birth — Subseq. —	At birth — Subseq. —	2	1	Nil	—	+	+
(3) 997	Naturally infected :— Died acute intoxication 3rd week of feeding.	At birth — Subseq. —	At birth — 1st week apprec. Subseq. —	2	1	Nil	—	—	—
(4) 1000	Naturally infected :— For 13 weeks.	At birth — Subseq. —	At birth — Subseq. —	2	1	Nil	No test made	—	—
(5) 1001	Naturally infected :— For 5 weeks (then killed).	At birth + dist. 1-2 weeks + apprec. Subseq. —	At birth + dist. 1-2 weeks + dist. 3rd week + apprec. Subseq. —	7	5	Nil	No test made	—	+
(6) 1002	Naturally infected :— For 14 weeks.	At birth — Subseq. —	At birth — Subseq. —	5	3	Nil	No test made	—	—
(7) 100	Naturally infected :— Commenced feeding expt. when 3-months old.	At 3 months' old — (3 days after feeding). 12-13 weeks + dist., after feeding. 15th week + dist. Subseq. —	At 3 months old + (8 days after feeding very marked) 1st to 18th weeks after feeding + Subseq. —	3	1	1	No test made	+	+
(8) 101	Naturally infected :— Commenced feeding when 4 days old.	At 4 days — Subseq. —	At 4 days — Subseq. —	2	1	Nil	—	—	—
(9) 102	Naturally infected :— For 15 weeks.	At birth — 2nd week — Subseq. —	At birth — 2-6 weeks + apprec. Subseq. —	3	1	Nil	+	+	+
(10) 103	Naturally infected :— 6 weeks (after 6th week died of white scour).	At birth — 2nd week apprec. 4-6 weeks + markedly	At birth + markedly 1st-6th weeks + markedly (decreasing 5th and 6th weeks).	2	1	Nil	+	+	+
(11) 104	Naturally infected :— For 13 weeks (commenced feeding when 4 days old).	1st 4 days — Subseq. —	At 4 days — Subseq. —	2	1	Nil	—	—	—
(12) 1003	Non-infected milk + living culture (5 c.c. broth culture) at each feeding :— For 12 weeks.	At birth — Subseq. —	At birth — 1st week after feeding + strong, then gradually declining to 10th week. Subseq. —	4	2	2nd calf	—	No test made	No test made
(13) 999	Pasteurised naturally infected milk :— For 13 weeks.	At birth — Subseq. —	At birth — Subseq. —	2	1	Nil	—	—	—
(14) 1004	Non-infected milk :— For 12 weeks.	At birth + dist. 1-3 weeks after feeding + (fairly dist.) Subseq. —	At birth — 1st week after feeding + dist. 2nd week + apprec. Subseq. —	8	6	2nd calf	No test made	—	+
(15) 1005	Non-infected milk :— For 12 weeks. Died mechanical pneumonia, after 21 weeks.	At birth — Subseq. —	At birth — Subseq. —	2	1	Nil	No test made	—	—
(16) 1006	Non-infected milk :— For 12 weeks.	At birth — Subseq. —	At birth — Subseq. —	7	4	Nil	No test made	—	—
(17) 1007	Non-infected milk :— For 12 weeks.	At 2 weeks — Subseq. —	At 2 weeks — Subseq. —	9	6	2nd calf	No test made	—	—
(18) 1008	Allowed to suck dam for 3 days after birth; then separated and fed on non-infected milk for 12 weeks	At 57 days (1st blood test) slightly + 10th week + dist. Subseq. —	57th day strong + declining to 12th week. Subseq. —	5	3	Nil	No test made	+	+
(19) 1009	Allowed to suck dam for 3 days, then separated and fed on non-infected milk for 12 weeks	At 17th day (1st blood test) + apprec.; also 5th week + apprec. Subseq. —	17th day strong +, declining to 6th week. Subseq. —	3	2	Nil	No test made	+	+

Table compiled from *Tech. Bull.*, No. 32, Oct., 1916, Mich. Agric. Coll. Expt. Sta.

were placed in his home herd where the abortion disease had never existed. Shortly the newly-purchased cows commenced to abort. Later cows in his original herd started to abort until the infection had become quite generally distributed. This man also maintained a herd of grade cows on another farm a short distance away. The same bull was used in both herds, as well as on neighbours' cows. None of these cows aborted, although the disease continued its havoc in the pure-bred herd. It should be noted that this bull gave a positive reaction to the complement fixation test for abortion, and so may be considered to have had a systemic infection, as well as having had every opportunity to act as a mechanical transmittor."

However, in spite of what now seems to be a generally admitted fact, namely, that the bull is not responsible for transmission in the great majority of abortion cases, a word of caution is necessary, having regard to points which must be borne in mind in formulating control measures based on the exclusion of infected animals. In the present state of our knowledge, as SCHROEDER points out, "the bulls must not be regarded as innocent carriers of abortion bacilli, as the expulsion of the bacilli from their seminal vesicles or other portions of their reproductive organs is not necessarily limited to the time of copulation, and we have no valid reasons to believe that abortion bacilli disseminated by bulls are less virulent than those which have their origin in cows."

It still remains to be seen whether infection *per vaginum* is possible otherwise than by means of the bull. Experimentally, the injection of massive doses of culture into this passage has been found quite capable of producing abortion (*Dept. Committee Report*, 1909, five positive cases out of eight), and MCFADYEAN and his co-workers (1913) obtained a distinct reaction, which became only just appreciable thirty-five days after infection, by instillation of culture into the vaginal passage of a virgin heifer. However, as pointed out in the Report referred to above, "in considering the relative importance of infection resulting from the more or less accidental admission of infective material from the floor or dirt of a cowshed, it must be borne in mind that, even when discharges from an infected cow do reach the floor or become mixed with excreta in the channel behind the cows, the chances must usually be against the bacilli gaining entrance to the genital passages, and that the number of bacilli which could be so admitted to the vulva or vagina under ordinary conditions must generally be small." The chances in favour of infection by this channel in the field must obviously be even greatly smaller. WILLIAMS (W. L.) asserts that once the uterine seal has formed, an effective barrier has been erected against the entrance of bacteria into the uterus via the vagina. Be that as it may, and especially in view of SCHROEDER'S observations on the fate of abortion bacilli introduced along this tract, there can be no doubt that "in the light of recent researches it appears actually doubtful whether cows ever become infected in consequence of casual or accidental admission of the bacilli into the genital passages" (MCFADYEAN, *Jl. R.A.S.E.*, 1913, p. 94). Further, in view of this important etiological statement, it can be unequivocally laid down that preventive measures, based upon the assumption that the virus of the disease gains entry by way of the genital passages are destined to meet with little or no success. "Frequent disinfection of the premises is no doubt advisable, but the repeated injection of disinfectants into the genital passages of healthy cows in order to safeguard them from infection must be condemned as being both useless and irritating" (MCFADYEAN, *loc. cit.*). Some writers have asserted, dealing with the relative importance of infection by the mouth and by the vagina, that the contagion can be carried from the mouth parts and implanted directly on the vulvar opening, and thus gain direct access to the uterus, for cows often may be observed adopting an attitude which would lend itself to such transference. The passage of the virus, in the event of such occurrence, is much more likely to operate in the opposite direction.

A possible channel of entry which has received some attention recently is the teat canal, especially in view of the results of work performed during the course of the last few years, which would go to show that next to the gravid uterus the udder is the predilection seat for the causal bacteria in the body. Experimentally, transmission along this channel has been accomplished by SCHROEDER and COTTON, and by COOLEDGE. A very close study of the distribution and persistence of the infection in naturally affected udders led the last-named author to suggest, in view of the fact that the rear quarters were the first to show the infection, that the genital discharges conveyed by switching of the tail or by running down the cow's hind quarters were the original source of infection, and that the infection could then be spread to the other quarters by the hands during the milking process. Once the infection had established itself in the udder, the milk became a carrier and a possible source of infection for years. In no case had the udder infection died out during the three years observations were made (*Michigan Agric. College Expt. Sta.* Bulletin No. 33, 1916). This mode of transmission may possibly operate sometimes between the udder and genital passages in the cow herself, but there is no evidence forthcoming to show that within a herd it is a method of spread worthy of attention.

Again, dealing with infection by the mouth, which is now generally accepted to be by far the most common method of transmission in natural circumstances, there is to hand a number of experimental data which would go to show that the ingestion of even considerable numbers of bacilli by no means invariably results in the

establishment of infection. There is sufficient evidence to show that calves from infected mothers and allowed to feed upon the infected milk secreted by these dams, do not manifest persisting signs of infection for any considerable time. Particularly significant in this respect are the results depicted by HUDDELSON (*Mich. Agric. Coll. Expt. Sta.*, 1916), who fed eleven calves upon naturally infected milk for a long period of time,and only one of them developed complement-fixing bodies to any marked degree; this calf was fed on the milk for thirteen weeks,and antibodies were discoverable in its blood for the first five weeks. All succeeding tests gave negative reactions. Again, a calf fed on non-infected milk (*i.e.*, milk from a non-infected cow) to which broth cultures of the bacillus were added with each feed of milk, developed a positive reaction which did not persist for any striking length of time, but disappeared while the mixture was being fed. (*See* Table.)

In one of the two yearling animals which were each administered two tubes of agar culture by the mouth, reported in MCFADYEAN'S experiments designed to throw further light on methods of infection, in 1913, failure to infect was indicated by constant negative results to the serum tests performed upon this animal (*Jl. Comp. Path. and Therap.*, 1913, p. 154).

SCHROEDER states: "Calves, so far as we have been able to determine, are immune; at least those which are exposed to infection during the first three to five months of their lives, and are known to have ingested an abundance of infected milk prior to weaning, if they are later protected from exposure, not only fail to show symptoms of abortion disease, but are also negative to abortion tests."

What this resistance to infection on the part of young animals signifies is difficult to understand, and it is open to several interpretations. SCHROEDER (*loc. cit.*) expresses the belief "that the susceptibility of cattle for the BANG bacillus increases from calfhood to sexual maturity; or, more definitely, that the organs of cattle in which the bacillus can maintain itself do not become a suitable habitat for it until considerable progress has been made toward sexual maturity. Heifers and bulls which become infected, I am inclined to believe, are not likely to be common elsewhere than in severely infected herds in which sanitation is treated as something of minor importance."

But it is reasonable also to assume that the infective material to which the various classes of animals gain access may vary somewhat in virulence, and that the progeny at least, while dependent on the milk derived from an infected mother, may derive a certain degree of passive immunity from it. It is readily conceivable that the few bacilli which must pass an almost latent existence in the milk cistern of a cow's udder, and which the calf has to withstand, perhaps differ in virulence considerably from the large numbers voided with the actively diseased uterine contents which contaminate the pastures grazed over by susceptible adult cows. That the virulence of different strains of the abortion bacillus varies very much, and that the same strain may become modified fairly readily in this respect, has been well noted, particularly by MOHLER and TRAUM, in experiments on small animals (*28th Rept. Bureau of Animal Industry*, 1911, p. 157).

(*To be continued.*)

The "Dahlia" Foot-and-Mouth Inquiry.

An old warship, H.M.S. Dahlia, for nearly a year past, anchored "somewhere off the East Coast," has witnessed mysterious comings and goings of famous doctors and veterinary surgeons, engaged in probing the problems of foot-and-mouth disease.

The Dahlia was acquired for the work of the Departmental Committee of the Ministry of Agriculture appointed to investigate the disease. The committee has Professor Muir, of Glasgow, as chairman, and includes Sir Stewart Stockman, the Ministry's chief veterinary officer, and Sir John M'Fadyean, principal of the Royal Veterinary College, Camden Town, London, N.W.

Laboratories were installed and accommodation provided for the animals, chiefly sheep and pigs, needed for the investigation. Naturally the ship has been full of the disease, and it has been the task of one inspector to see that no infection spread to the shore.

The scientists' report may be expected towards the end of the year.

CUPAR ANTHRAX INVESTIGATION.

A committee of the Executive Committee of Fife County Council met recently at Cupar in connection with the serious outbreak of anthrax at the farm of Moonzie.

It was reported that twelve bullocks had died from anthrax, and that the farm had not yet been declared free of disease. By order of the Board of Agriculture all the animals had been inoculated.

Some discussion took place as to the probable cause of the outbreak, and it was stated that at one portion of the field where the outbreak occurred a former tenant had been in the habit of burying carcases of diseased animals. The "cemetery" thus created was on marshy ground, and for the first time for a great many years it was quite dry this season. Some of the members were of opinion that the spores of the disease of former anthrax victims had found their way to the surface, and so affected the stock grazing on the field.

It was also stated that a farmer in the neighbourhood of the affected area had found some dead hares on his land, and he wondered if that had any connection with the anthrax outbreak.

The Clerk was instructed to write the farmers in the district notifying them if they found dead hares on their farms to send them at once to the veterinary inspector.

The Veterinary Record.

10th September, 1921.

IMPETUOUS ZEAL.

Close observers confidently anticipated a post-war phase of increased activity which, if carefully fostered and judiciously applied, should make for professional advancement. This newly-awakened interest is now evident within our body corporate, and is indeed a very welcome change to the pre-existing lethargic state with which the veterinary profession has so often and at times, perhaps justly, been credited. Valuable as this altered condition undoubtedly is, if the best results are to be obtained from a renewed professional zeal, the time has undoubtedly arrived when judicious application is most urgently demanded. The spirit of unrest which is ever a mark of post-war conditions has swept this country, as it has those of the other belligerents, and in its progress has not left our profession untouched. Now, as never in the past, should we have a care that good and nothing else is made of this exuberance of energy. It cannot be denied that substantial progress has been made in numerous directions. The mere tone of recent contributions at professional meetings, and of the discussions which have resulted therefrom, have vibrated with scarce restrained enthusiasm, impatience for the rapid realisation of advancement and intolerance of necessary delay.

Reconstruction, that magic expression of but a short while ago, is now well under-way, but the process, if it is to provide a result worthy of our generation and meet to be handed to posterity as our interpretation of modern requirements, must necessarily be carefully planned and as carefully executed.

It will indeed be a calamity if this priceless zeal be misapplied, so discrediting future endeavour and inviting the return of impenetrable lethargy.

Clinical and Case Reports.

Carcinoma of the Bladder.

By Fred. J. Taylor, M.R.C.V.S., Shaftesbury, Dorset.

Subject.—Red shorthorn, four years old.

History and Symptoms.—In March last, this animal showed indefinite symptoms of cystitis, by intermittently passing blood stained urine, sometimes straining slightly whilst urinating. She gradually lost condition, with decreasing lactation, until the symptoms became more perceptible and acute, and when first seen by me in July she was constantly passing bloody urine with great difficulty. The catheter was introduced, after somewhat troublesome manipulation, and a large quantity of fœtid urine was liberated, after which an enlargement was located at the neck of the bladder, which felt suspiciously like a malignant growth. As further treatment did not appear to be indicated, the cow was killed.

Post Mortem.—A large, hard, and papillomatous growth was found at the neck of the bladder, and almost entirely occluding the meatus. On microscopical examination the tumour proved to be a carcinoma. I should be interested if any reader can suggest a possible cause, or quote a similar case.

Trypan Blue in Malignant Jaundice in the Dog.

By J. W. Hall Masheter, M.R.C.V.S., Newnham.

Subject.—Fox terrier bitch, 12 months old, brought to Infirmary on July 2nd.

Symptoms.—Off food for the last day or two, constipated, and all visible mucosæ yellowish.

Gave cholagoune pills daily for four days.

July 6th I was asked to see her again, and found her very thin, eyes sunken, conjunctiva, and all visible mucosæ almost liver colour, tongue the same, and the skin of abdomen, thighs, etc. a very bright yellow.

Gave 1 drachm of 1 per cent. solution of trypan blue (P. D. & Co.) hypodermically.

July 7th.—Bowels acting freely and had eaten a little bread soaked in milk. Ordered raw meat minced—½ ounce in the day.

After this the dog rapidly recovered her spirits and appetite. No further medicine was given. A week later all the membranes and skin had cleared up and the bitch had a tussle with a big rat, which she managed to kill.

Association Reports.

Royal Counties, Southern Counties and South-Eastern V.A.

Combined Meeting at Folkestone.

The third combined meeting of the Royal Counties, Southern Counties, and South-Eastern Veterinary Associations was held at the Masonic Hall, Folkestone, on Thursday, June 23rd, during the session of the Congress of the Royal Sanitary Institute.

Mr. T. F. Hogben, President of the South-Eastern Veterinary Association, occupied the chair, and there were also present Major G. W. Dunkin, Prof. G. H. Wooldridge (F.), Prof. F. Hobday (F.), A. T. Crowther, G. V. Gunning, J. R.

Hayhurst, W. W. Gulleford, Major P. J. Simpson (F.), J. B. Buxton (F.), G. P. Male, H. P. Hogben, and others attending the Sanitary Congress.

Letters of regret at inability to attend were received from numerous members.

Correspondence.—Letter of acknowledgment of previous resolutions was received from the N.V.A.

A letter of resignation of the position of Secretary of the combined meetings was read from Mr. G. H. Livesey and discussed. The resignation was accepted with regret, and the opinion expressed that probably the work of the General Secretary could be undertaken by the local Secretaries of the districts in which the meetings were held. It was decided to defer the matter for further consideration at the next combined meeting.

The PRESIDENT then requested Mr. W. M. Scott, F.R.C.V.S., to read the paper which he had prepared for the meeting.

Mr. Scott's paper was as follows:—

POLL-EVIL AND FISTULOUS WITHERS IN EQUINES

(*Their Patho-clinical Relation to Modern Medical Surgical Biological Therapy*).

Judging from the paucity of our literature, if the surgical side is excluded one would think these conditions are really of little scientific or economic import, which indeed is not the case. An animal suffering from either disease may possess a certain working capacity, but the time will surely come when he must be laid aside, and no one will deny treatment will then be as expensive as it is prolonged, exercising to the utmost all the skill of the attendant and all the patience of the owner. In choosing a subject upon which to address you, I wanted one which would give me the best opportunity of breaking away from the beaten track of orthodoxy; and who will deny that these diseases give plenty of scope for energetic spade work? To me they appear to stand out on our professional horizon as rough uncut diamonds, reflecting of themselves little light and absorbing less. Would that a cunning workman arose to so manipulate them that their facets would shine with increased brilliance, bringing kudos to our calling.

Definition.

Like many other examples in our nomenclature, the term "poll-evil" is as unscientific as it is crude, and while it may be descriptive enough for the man in the street, to the tuned ear of the scientist it sounds discordant. Fistulous withers is, of course, in itself inaccurate, for, as you know, in some cases and at certain stages no such thing as a *fistula* exists. In defining any disease the definition requires to be both brief and accurate. As an alternative, I would therefore suggest "carbuncle or trauma of the poll and withers."

Causes, Predisposing and Actual.

Before these can be satisfactorily discussed, it is well to clarify the points, (1) What constitutes poll-evil? (2) What constitutes fistulous withers? Where one gets an effusion of serum into the bursa of the poll, or a similar effusion into the subcutaneous structures of the withers, and there is no bacterial contamination in these areas, true poll-evil and fistulous withers, I opine, do not exist. It must not be denied, however, that the distinction may be more *academic* than *practical*, inasmuch as one has an animal suffering from these local effusions, which in themselves may be sterile to-day and infectious to-morrow, without any positive clinical evidence of the transformation. These effusions are brought about by local injuries: in the case of poll-evil, hanging back when haltered, knocking the head against the beams of doorways or low roofs, and so on; and in fistulous withers, rolling on hard ground, badly-fitting saddles and collars, while in the case of hunters, particularly those with thick, fleshy withers, hunting in a hill country. Heredity is also an important predisposing factor, and by that I mean the transmitted lowered protective power to combat bacterial invasion. A high blood calcium content predisposes to the development of these diseases. No doubt many of you have noticed, when operating, the blood coagulates very rapidly. I have in several instances measured the content, and found it invariably high, which, from a therapeutical point of view, has an important bearing. A high calcium content means increased coagulation power, which acts as a barrier to the rich bacteriocidal serum reaching the infective foci, with the result that *positive* chemiotaxis and resultant phagocytosis is reduced. Lastly, a depressed condition of the system consequent upon such diseases as influenza, strangles, and extensive septic trauma are important predisposing factors.

The causal agents, of course, are the pyogenic organisms, the most important of which are the streptococci and the staphylococci, occasionally the bacillus coli, bacillus pyocyaneous.

From an extensive examination of pus obtained from cases in my own practice, and swabs sent me by colleagues, I have found the ratio of organisms works out as follows:—Streptococci, 48 per cent.; staphylococci, 42 per cent.; bacillus coli, 7 per cent.; bacillus pyocyaneous, 3 per cent.; while the streptococci and staphylococci in combination work out in 73 per cent. of the cases. The unnamed organisms present which were looked upon as probable aliens are not calculated. The interesting point now arises here, how do those pus-producing organisms gain access to the affected areas? If cutaneous inoculation is put forward, I may at once say I have no use for this theory in the large majority of cases seen in general practice. You have all seen extensive injuries to the poll and withers without the development of poll-evil or fistulous withers; moreover, I have endeavoured artificially to produce those diseases, but without success. I therefore feel sure we must look deeper into this point. Auto-infection, I believe, of *post facto* origin, is the root cause of many of our cases,

and I have taken the trouble to look into previous histories of many patients, and have been struck with the large number which have suffered from previous severe attacks of influenza or strangles or injuries of an extensive septic nature. The conclusion, therefore, has been forced upon me that the connecting link between those conditions and the diseases under consideration is not so fantastic as many may be inclined to think; moreover, we know that pathogenic organisms lead a saphrophytic existence on the healthy respiratory, alimentary, and urinogenital mucosæ. In other words, a kind of latent bacterial "storehouse" is established. As opportunities occur and circumstances become favourable, these organisms, leading a harmless existence on the mucosæ, or shut up in the corner of some gland or organ, break through into the circulation. Many are undoubtedly destroyed in the blood stream, and if they pass along the portal system, in the liver. Some reach a terminal, such as an injured poll or withers, and if the bacteria are sufficiently aggressive, a focal infection becomes established. These, in my opinion, are briefly the real factors at work in the production of poll-evil and fistulous withers as seen in general practice in most cases.

Interpretation of Pathological Phenomena.

The practitioner who interprets correctly the pathological phenomena is likely to be a more successful therapist than he who ignores *in toto* this most valuable stepping-stone. As the result of an injury to the poll or withers, effusion of serum, and, in severe cases, extravasation of blood, takes place. If this separate serum or blood remains sterile, the main portion is gradually taken up by the absorbents, and all that remains will be a slight thickening (fibrosis) consequent upon an irritative cellular proliferation. Should, however, pathogenic organisms gain a footing on this already depressed area, their multiplication will be rapid, and their toxin production profuse. These at first have a stimulating effect upon the local tissue cells which are rapidly reproducing, and they and the free leucocytes are actively engaged "phagocyting" the invaders. Many organisms by this process and by the lysins in the serum die, nature very exceptionally gaining the mastery and resolution in the ordinary course following. On the other hand, if the bacteria are the victors, the leucocytes nearest the bacterial foci undergo cloudy swelling, granular degeneration, and death, or they may be killed outright. Those further away are sickly, while the cells at the outer fringe from the toxic zone are hyper-active. About this time the central zone is made up of a mass of dead and living cells and bacteria floating in a turbid serum. Surrounding this a new cellular wall, ever increasing in density, is in the process of making, cutting off the infective zone from the adjacent healthy tissue. The pus now formed and laden with dead cells and bacteria becomes charged with a tryptic ferment, which digests in time the cellular wall, clinically constituting the pointing and bursting of the abscess; but this process, as you know, may be long delayed, due largely to a deficiency of the tryptic ferment, consequent upon a defective leucocytosis at the outset, or an over-developed *anti-tryptic* power of the blood itself. The surgeon must therefore look upon the tryptic ferment as a friendly agent, inasmuch as it helps to bring about separation of the dead from the living. Where bacterial aggression is very acute, cellular death may take place *en masse*, resulting in time in an attached or detached slough. This is particularly noticeable where such lowly vascular structures as ligamentous tissues are involved. In advanced cases these sloughs may become impregnated with lime salts, constituting calcareous degeneration. Such conditions are particularly common in old-standing cases of poll-evil, and I need hardly remind you that these deposits add considerably to the gravity of the case. In other cases an acute irritative fibrosis is set up, culminating in a slightly sensitive hard swelling, which, if cut into, shows one or more degenerative foci containing gelatinous-looking pus often tinged with blood. In other words, cellular proliferation has gone on at such an enormous rate that suppuration appears to have been thwarted from the outset. For this phenomenon there must be a reason. It is a well-recognised fact that immediately the tissues become invaded by pus-producing organisms an anti-tryptic power of the blood develops, and if this becomes exaggerated, the auto-digesting tryptic ferment in the pus becomes neutralised, so that a continued induration instead of abscess sac formation takes place.

Now, gentlemen, I should like to say a word with regard to the pus itself. I venture to think the old-time surgeon held a more logical view in regard to pus than the present-day practitioner. At any rate, he recognised two kinds, healthy or "laudable," and unhealthy pus, while in these later days we are inclined to look upon all pus as unhealthy; this, however, requires qualifying. A clinician may say pus is a morbid fluid, and as such is of interest only to the pathologist; but I submit that if we interpret the teaching pus is capable of conveying, we shall gain much useful information. The pre-Lister surgeon looked and hoped for a thick, tenacious, creamy pus, for he knew, without being able to explain why, that with a wound discharging such pus all was well with his patient; whereas if the pus was thin, watery, and deficient in quantity, he dreaded the development of his *bête noir*, blood poisoning. We know now that if the pus is "laudable," the natural protective body forces are putting up a good fight, rich bacteriocidal serum is saturating the infected area, an enormous surcharge of leucocytes with some lymphocytes and eosinophiles are thrown into the fray, many dead or dying, charged with toxins and bacteria. On the other hand, if the pus is thin and watery, lacks adhesiveness and body, the "phagocytic" elements are deficient, while the bacteria are excessive. This

may be due to a variety of causes: (1) The bacteria may be so aggressive that nature's protective mechanism is thrown out of gear at the outset; (2) a lowered opsonic index thwarting phagocytic effort; (3) a high calcium content preventing phagocytes from reaching the infected area; (4) the abscess or sinus wall may become so indurated that lavage with bacteriocidal serum is impossible and phagocytosis barred; (5) a low tryptic ferment obtained from the disintegrated leucocytes; (6) a core of necrosed tissue forming in itself an excellent bacterial media, but into which the phagocytes cannot enter to scavenge owing to the danger of death by oxygen starvation.

It will therefore be seen that pus does convey to the trained mind a valuable message, and I submit it is the surgeon's duty to interpret that message aright and treat according to scientific and rational principles.

Symptoms.

In mild and recent cases of poll-evil, where distension of the bursa with serum has taken place, a bi-lateral, non-painful swelling behind the ears is noted. This local condition may remain as such for a long time, or it may gradually become absorbed, or the swelling may increase, become painful to the touch, and, as time goes on, one or more fluctuating centres may be detected. Lastly, it may culminate in a hard, indurated fibrous swelling. Where a pronounced abscess formation takes place, this will in due course burst if not previously lanced, leaving a pus-sodden cavity or cavities, which may or may not contain necrotic tissue or even calcareous deposits. In advanced cases the head is carried stiffly, the cervical muscles may be atrophied, the nose may be protruded, and there is usually difficulty in feeding from the ground. In very advanced and neglected cases, particularly where the pus is deep-seated and covered by a thick and indurated fibrous crown, burrowing may take place into the spinal cord, setting up cerebro-spinal-meningitis, paralysis, and death. In the case of fistula withers, the swelling may be uni-lateral or bi-lateral; it may be hard and fibrous or fluctuating. In the case of the latter, on lancing the cartilaginous prolongation of the scapula and even the superior spines of the vertebræ may be laid bare, adding to the complexity of the case. The worst forms, however, are to be found in those cases where pus has burrowed between the scapula and the ribs, in which case locomotion is greatly interfered with, the animal being usually incapable of feeding from the ground unless it flexes the leg on the affected side and extends the limb on the opposite side.

(*To be continued.*)

Army Veterinary Service.

LONDON GAZETTE WAR OFFICE TERRITORIAL FORCE.

September 1st.—Major J. E. L. Still, T.D., relinquishes his commission on account of ill-health (September 2nd), and retains the rank of Major, with permission to wear the prescribed uniform.

Diseases of Animals Acts, 1894 to 1914. Summary of Returns.

Period.	Rabies. Cases Confirmed. Dogs.	Rabies. Cases Confirmed. Other Animals.	Anthrax. Outbreaks confirmed.	Anthrax. Animals attacked.	Foot-and-Mouth Disease. Outbreaks confirmed.	Foot-and-Mouth Disease. Animals slaught'd as diseased or exposed to infection.	Glanders (including Farcy).* Outbreaks reported by the Local Authorities.	Glanders (including Farcy).* Animals attacked.	Parasitic Mange. Outbreaks reported by the Local Authorities.	Parasitic Mange. Animals attacked.	Sheep Scab. Outbreaks reported by the Local Authorities.	Swine Fever. Outbreaks confirmed.	Swine Fever. Swine slaughtered as diseased or exposed to infection
GT. BRITAIN.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Week ended 27th August, 1921	...	...	10	13	...	...	...	...	18	23	2	15	5
Corresponding Week in 1920	1	...	17	19	2	71	...	...	24	32	3	20	6
Corresponding Week in 1919	3	...	6	6	...	...	...	...	54	97	2	36	20
Corresponding Week in 1918	...	...	7	8	...	...	...	...	40	72	3	14	4
Total for 35 weeks, 1921 ...	22	1	363	469	43	2958	9	25	1746	2699	406	874	301
Corresponding period in 1920	8	...	289	347	72	9559	10	17	3006	5052	296	1413	557
Corresponding period in 1919	139	3	136	174	25	1557	19	46	4026	8081	220	1542	687
Corresponding period in 1918	...	...	176	202	...	...	23	65	3449	6532	252	995	401

NOTE.– The figures for the current year are approximate only. *Excluding outbreaks in Army horses.

IRELAND. Week ended 27th August, 1921	...	...	...	...	...	...	Outbreaks 1	4	1	26
Corresponding Week in 1920 ...	...	...	...	...	...	...	1	8	...	...
Corresponding Week in 1919 ...	...	...	...	...	...	...	...	1	1	...
Corresponding Week in 1918 ...	...	...	...	...	...	...	...	1	...	1
Total for 35 weeks, 1921	...	...	7	77	...	...	68	183	78	426
Corresponding period in 1920 ...	1	1	...	...	1	3	83	195	8	25
Corresponding period in 1919 ...	...	...	...	...	1	1	123	172	25	74
Corresponding period in 1918 ...	2	2	...	...	...	...	87	203	17	58

NOTE.—The figures for the current year are approximate only.